or more and 0.20 inch or more is even more pronounced than that of 0.01 inch or more.

To illustrate this point, see Figure 5. The mean frequencies for the day for each amount, 0.01 inch, 0.10 inch, and 0.20 inch are shown as 100 per cent, and the hourly frequencies are shown in percentage of the average. By this means it is easily seen that the amplitude of the daily variation is greater for the larger amounts.

If we use the number of days with 0.01 inch or more in a month as an indication of the frequency of 0.20 inch or more in any period for which insurance is to be issued, we are assuming that the hourly frequency is a straight line as represented by 100 per cent in Figure 5, whereas the frequencies at 9 a. m. and 9 p. m. differ by more than 200 per cent.

In conclusion, it is evident that we can determine the frequency of any given amount in any stated period in only one way and that is by considering the individual occurrences of that amount in the stated period and grouping these values about a mean. There is a growing need for information of this character, both for rain insurance and for agricultural purposes. It is clearly evident that averages and means for rainfall data are not trustworthy as an indication of future occurrences.

Studies of this character bring to light certain peculiarities in the distribution of rainfall locally, not otherwise suspected.
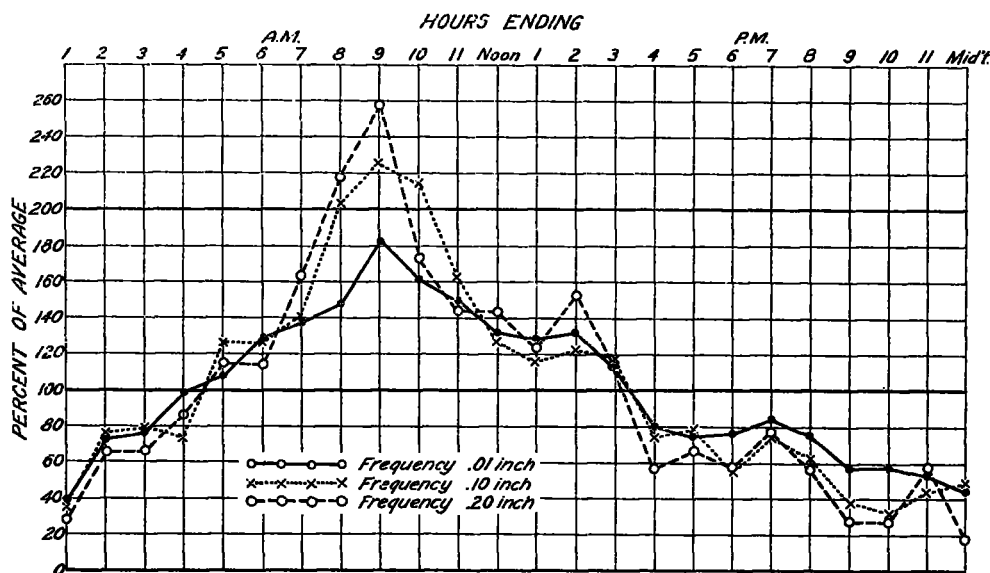

FIG. 5.—Hourly frequencies of 0.01 inch, 0.10 inch, and 0.20 inch, expressed as percentage of the average hourly frequency.

LOWERING OF KANSAS RIVER CHANNEL AT TOPEKA, KANS.

By S. D. FLORA, Meteorologist.

[Weather Bureau, Topeka, Kans., October 12, 1922.]

The frequent occurrence of record-breaking low stages in the Kansas River at Topeka without any apparent cause in the way of diminished precipitation in the drainage basin of the stream led to an investigation which seems clearly to show a lowering of the river channel of about a foot in the past 5 years and slightly more than 3 feet in the 18 years since the record was begun. Only stages for the 6 warm months, April to September, inclusive, of each year were considered in the investigation, as the record is not complete for all winter months.

Two methods were used in this study. The first was the utilization of a "floating" 5-year average—that is, by obtaining the average stages for successive 5-year periods from the beginning of the record and plotting them. (See fig. 1.) The second was the construction of a trend from a formula in use by statisticians, which has the advantage of making it possible to plot the change from the first year of the record to the last. (See fig. 2.) The graph representing this trend was obtained by means of the accompanying table.

It is interesting to note that the two methods corroborate each other closely. Figure 1 shows a lowering of the stage of 1.2 feet in the last 5 years of the record and Figure 2 a lowering of 0.95 feet, while from 1909—the first year for which a 5-year mean is available—to 1922

the change is 2.80 by Figure 1 and 2.66 by Figure 2. The straight-line trend extended to the first year of the record shows a total lowering of 3.42 feet in the stream channel in the 18 years under discussion.

Table showing trend of river stages at Topeka, Kans.

A. Year.	B. Average gauge height.	C.	D.	E.	F.
1905	9.5	−17	−161.5	289	8.76
1906	7.6	−15	−114.0	225	8.57
1907	6.7	−13	−87.1	169	8.38
1908	10.4	−11	−114.4	121	8.19
1909	8.4	−9	−75.6	81	8.00
1910	7.8	−7	−54.6	49	7.81
1911	6.4	−5	−32.0	25	7.62
1912	7.0	−3	−21.0	9	7.43
1913	5.3	−1	−5.3	1	7.24
1914	5.5	1	5.5	1	6.86
1915	11.1	3	33.3	9	6.67
1916	6.9	5	34.5	25	6.48
1917	5.8	7	40.6	49	6.29
1918	4.9	9	44.1	81	6.10
1919	7.5	11	82.5	121	5.91
1920	5.7	13	74.1	169	5.72
1921	5.5	15	82.5	225	5.53
1922	4.9	17	83.3	289	5.34
Sum	126.9		−185.1	1,938	
Average	7.05				

1938÷2=969.
−185.1÷969=−.19=yearly change trend.

EXPLANATION OF THE TABLE.

A is the year to which the data apply.

B is the average gauge height for the 6 months, April to September, inclusive.

certainty that the flow has not diminished with the lowering of the surface of the stream 3.42 feet since 1905, but it seems reasonable, in the light of the past five years' record, to assume that it has not.
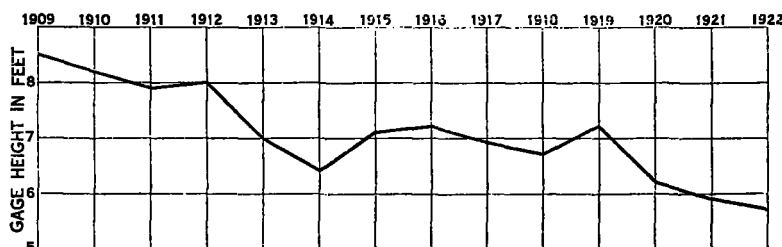

FIG. 1.—Trend of 5-year averages of river gauge readings at Topeka, Kans., for the summer months, April to September, inclusive. The value for each year is the average stage of the five years immediately preceding.
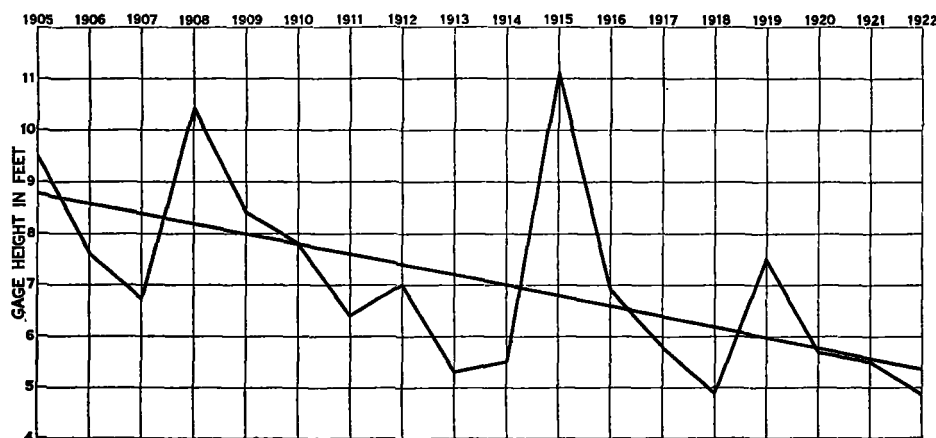

FIG. 2.—Trend of river stages at Topeka, Kans. The broken line indicates the trend of average stages for the 6-month period April to September, inclusive, of each year from the beginning of the record. The straight line is the trend, obtained mathematically.

C is the number of years distant from the middle of the record, multiplied by 2 for convenience in further computations.

D is the product of B × C.

E is the square of C.

F is the adjusted trend, obtained as follows: The average stage of the series, 7.05, is put as the mean trend stage at the middle of the series. The quotient of the sum of the column headed D divided by one half the sum of the column headed E (− 185.1 ÷ 969, or − .19) is made the yearly change or trend from the mean trend stage, which is 7.05. The trend is obtained by subtracting the trend change, − .19 from 7.05 once for each successive year prior to the middle of the series and adding it once for each successive year subsequent to that point.

That this decrease in the average gage height has not been attended by a corresponding deficit in stream flow is shown by a study of the rating curves that give discharge in second-feet for the past five years, prepared by the United States Geological Survey.

The rating curve for 1917, the first year for which discharge measurements were made, and that for 1922 are given in Figure 3. No stages lower than 3.5 feet occurred in 1917, hence it was not possible to extend the curve for that year as low as the one for 1922, when a stream-flow measurement was made at a stage of less than 2.5 feet. However, the curves show that at a stage of 2.5 feet in 1922 the river had a discharge of 790 second-feet, which is practically the same as its discharge at 3.5 feet in 1917, indicating that approximately as much water passed the gauge in 1922 as in 1917, when the stage ranged a foot higher. In the absence of discharge measurements prior to 1917 it is impossible to say with
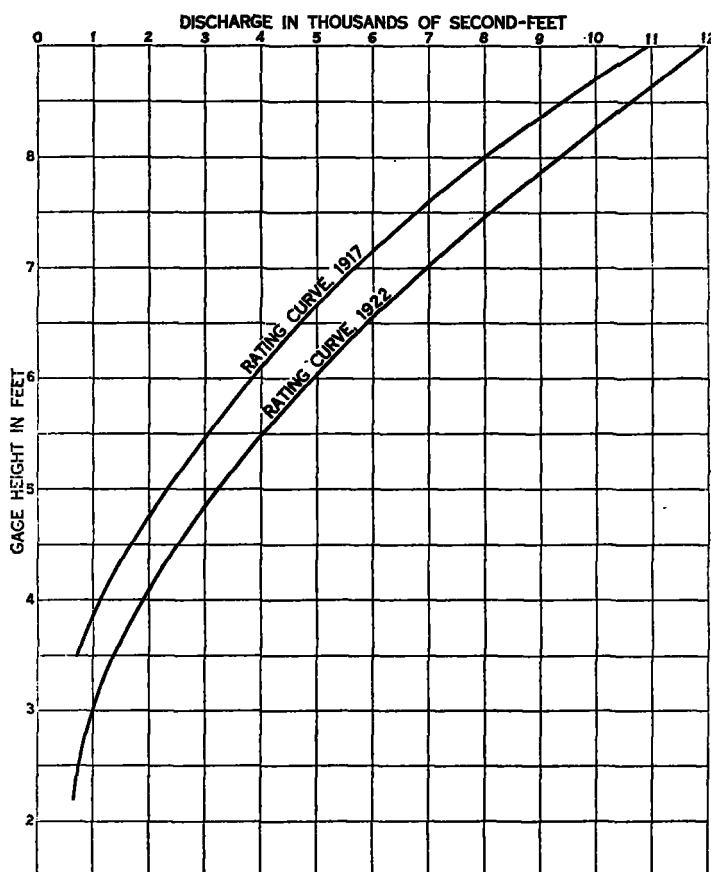

FIG. 3.—Change in rating curve of discharge of Kansas River, at Topeka, Kans.

The cause of the lowering of the channel is not far to seek. The sand of which the river bed is composed was long ago found to be of excellent quality for concrete work and almost 200,000 cubic yards are removed annually in the immediate vicinity of the gage and for a distance of half a mile below it for this purpose. Evidently this has lowered the control of the stream channel for some distance in this particular section of the river. In the absence of other gage readings nearer than Wamego, 35 miles upstream in an air line, and Bonner Springs, about the same distance below, neither of which has a record covering more than a few years, it is not possible to state how far this lowering effect has extended, but rating curves of discharge for the past five years at those places do not suggest any material change in the river bed, also there has not been much sand-dipped out of the river at either point.

It is difficult to estimate just what effect this lowering of the river channel at Topeka will have on high stages. Absence of high water during the last two years has prevented obtaining discharge measurements above 11 feet, but the approach of the rating curve of 1922 toward that of 1917 at higher stages indicates that at flood stage, 21 feet, there will not be much difference between the present volume of water passing the gage and the amount that passed at the same stage several years ago. However, the matter is worth investigation, especially as the decrease in height of the stages is a progressive affair and may go several feet farther in the next few years.

An immediate effect of the lowering of the stages is that it has been necessary to tear out the concrete floor of the well in which the float of the self-registering gauge at Topeka operates and lower it more than a foot at a considerable expenditure of time and money. When the gauge was installed five years ago it was assumed that it would register any low stage that might occur and this was borne out by past records, but on several occasions in the last year of the record the river was so low the float rested on the bottom of the well.

SNOWFALL AND THE RUN-OFF OF THE UPPER RIO GRANDE.

By CHARLES E. LINNEY, Meteorologist.

[Weather Bureau Office, Santa Fe, N. Mex., December 21, 1922.]

SYNOPSIS.

The run-off which appears in the upper Rio Grande is almost wholly derived from the melting of snow that falls on the elevated parts of the drainage basin in Colorado and New Mexico. Statistics are presented showing the mean monthly and annual snowfall as derived from an average of 10 stations in Colorado and 12 in New Mexico for the period of years, 1909–1922. The measured discharge of the Rio Grande, near Buckman, N. Mex., as determined by the United States Geological Survey is also given for the corresponding period and for earlier years.

The average annual snowfall is 97 inches. Assuming that the equivalent of the snow was 0.08 inch of water per inch of snow, and assuming further that there was no loss by diversion or otherwise and that but 29 per cent of the precipitation was measured as run-off, that amount of snowfall would correspond to 1,332,000 acre-feet for the area above Buckman, N. Mex. This amount corresponds very closely with the average run-off for the entire term of years but is somewhat below the average for the 13 years, 1909–1922. The uncertain factors in the above approximation are the water content of the snow, diversion, and other losses which can not easily be approximated.

In a consideration of the snowfall in connection with the run-off of the upper Rio Grande it is obvious that the calendar year is unsuited to the discussion or tabulation of data; rather should the year conform, in fair measure, to the natural cycle of snowfall and melting, and an effort be made to choose a period which will most nearly set apart the run-off which can be expected from snow, the resulting water to be measured as the stream discharge. After some consideration of the probable date when practically all snow water has found its way into the stream, I have chosen a year (or probably better, a cycle) to begin with the first of August. But in this choice it is admitted, of course, that there is an intermingling of rain and snow. It is thought, however, that the date chosen sets forth a cycle that is least affected, except one that would completely eliminate the late spring, summer, and fall run-off. In some of my figures I have done this, setting forth the results from snow alone, which will be apparent in the discussion.

THE PRECIPITATION OF THE DISTRICT.

The precipitation of winter which occurs over the southern Rocky Mountains pertains to the Pacific weather type, somewhat obliterated and diffused by the distance from the ocean. The humid winds of the Pacific are drawn across the region by the influence of low-pressure areas over regions near or remote, and step by step in its journey eastward the atmosphere discharges its moisture over the graduated plateau and mountain ranges, till it reaches the crowning peaks where occurs its maximum fall, as, for instance, around the rim of the San Luis Basin in Colorado and over the great crests of the Sangre de Cristo in New Mexico, between Taos and Colfax Counties, attaining there a maximum snowfall of probably 300 inches annually. Altitude has much to do with this; in fact it is probably the most important factor, next to the eastward movement of the moisture-bearing winds. General Greely gives the following table of altitude areas and precipitation for Colorado and New Mexico.[1]

State.	Elevations (feet).	Area (square miles).	Cubic miles, precipitation.	Average precipitation (inches).
Colorado............	4,000 and less.....................	8,773	1.5	11.15
	4,000 to 5,000....................	18,031	3.2	11.78
	5,000 to 7,000....................	31,314	6.1	12.74
	7,000 and over...................	45,885	9.2	13.12
Whole State.........		104,000	20.0	12.61
New Mexico.........	4,000 and less.....................	6,996	1.1	10.14
	4,000 to 5,000....................	34,407	6.1	11.59
	5,000 to 7,000....................	57,503	12.4	14.13
	7,000 and over...................	22,300	5.6	16.34
Whole State.........		121,200	25.2	13.62

In other words, considering New Mexico only, 71 per cent of the possible precipitation of the State occurs above 5,000 feet upon 66 per cent of the land area, while over the really worth-while elevations for the storage of snow (7,000 feet and over) only 22 per cent of the precipitation occurs upon less than 20 per cent of the land area. The ratio is somewhat greater for the Rio Grande drainage, since but a small part of it is below 5,000 feet, and a relatively large part is above. A very considerable part of the 22,300 square miles of the State which is above 7,000 feet is within the drainage area of the Rio Grande, but not within the district under discussion, which includes only the northern part of New Mexico, an area of approximately 6,400 square miles, and the southern part of Colorado, an area of approximately 7,300 square miles.

[1] Irrigation and water storage, Ex. Doc. No. 287, 51st Cong., 2d sess., 1891.